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# Study the Effect of Aluminum Variation on Hardness &Aluminum Loss in Zn-Al Alloy

Mr. D. R. Raut, [1] Mr. S. H. Poratkar[2]
[12]*Yeshwantrao Chavan College of Engineering, Nagpur-441110*

***Abstract:*** *The objective of this research is to study the hardness &aluminiumloss with percentage variation in Aluminium content added to zinc. As there is a method for coating known as Galfan is available, in which combination of 95%zinc and 5% Aluminium is used for protecting steel from corrosion.As there are not much details available about why this composition is used Zinc-5%Al, we are interested in study of effects of different composition of Aluminum with Zinc, so we study the effect by adding different composition 2.5%,4.5%,6.5%,8.5% & 11.5% Aluminum in Zinc, for this study we are using hot dip galvanizing process for studying this coating. Hot-dip galvanizing is widely used to improve the corrosion resistance of steel. To obtain high-quality coatings, some alloy elements are added to the zinc bath. Aluminum is one of the most important elements in galvanizing.Fe-Al phase diagram indicated thatα Fe is obtained between 1 to 11% of AluminiumGalfan alloy consist of 95% Zn and 5% Al. It was decided to study the effect of variation in Al content in Zinc-Aluminium alloy .Also during melting of this alloy we wanted to observed loss of Al due to oxidation hence the above compositions were decided.*

***Keywords:*** *Galfan, mildsteel*

## I. INTRODUCTION

In the zinc bath various elements are added in order to improve the melting characteristics of zinc and / or of the layer deposited on the steel support.

Aluminiumis added to the zinc-plating bath in a continuous flow of the steel strips/plates at a rate of 0.1-0.3% (optimal 0.14-0.17% [1]. Aluminium is added primarily to act as a brake to the reaction between zinc and steel support. Reducing the iron-zinc reactions results a decrease in the brittle intermetallic compound layer which has a negative impact the layer adhesion and plasticity. Because, compared with zinc, it has a higher affinity to iron; the aluminium present in the zinc bath will quickly form the Fe2Al5-XZnX compound on the steel surface. This ternary compound arranged in a thin layer onto the steel support will limit the diffusion processes leading to the formation of Fe-Zn intermetallic compounds [2]. The aluminum content in the layer will be much higher than that in the zinc bath. At 0.14% Al in the bath, the entire zinc coating (Including the ternary alloy layer) contains about 0.20% Al [2].

We know that hot dip galvanized coating has excellent electrochemical protection (also known as the expense of protection), when the coating damages, the coating of electrochemical protection can effectively protect the substrate and prevents corrosion, galvanized coating layer also has welding protection. Thermal aluminum coating has excellent atmospheric corrosion resistance and heat resistance, but at the expense of welding and poor protection. The new material (Galfan) is integrated zinc and aluminum possessing coating advantages of both [3]. Galfan is a 5% Al + 95% Zn coating with a small amount of mischmetal (Cerium, Lanthanum Neodybium) [4]. Mischmetal addition, containing lanthanum and cerium additions upto about 0.5%[5]. As per ASTM B750 the specification covers GALFAN, zinc- aluminium – mischmetal (Zn-5Al-MM) alloy is used in the production of hot dip coating on the steel. Cathodic protection provided by Galfan is more or less the same as that for galvanizing, while general resistance to corrosion is up to twice than pure Zn [6].

Galfan is a trademark for hot dip galvanized steel sheet or wire covered with zinc 5% aluminium alloy coating,the composition of which is near the eutectic point in the Zn-Al equilibrium phase diagram[7,8]. Two compositions based on additions to the eutectic composition have been reported: small composition metal additions containing lanthanum and cerium up to about 0.5%[9,10],and addition of 0.5% magnesium[11].

Shih reported that the nucleation and growth of Fe-Al intermetallics deplete the melt adjacent to the steel surface in Al. If the dipping time is longer and the depletion continues, the usual Fe-Zn phases can be developing [12]. According to Fe-Al-Zn ternary phase diagram at 4500c, [13, 14], the delta phase will be in thermodynamic equilibrium with the alpha iron, as well an Fe2Al5 phase layer. According to Urednicek and Kirkaldy[15] and Perrot et al[14], the delta phase could dissolve up to 8 wt%Al, therefore if the delta phase has been nucleated on the steel surface it would be in equilibrium with the Galfan bath.

The present study is intended to evaluate experimentally the influence on the hardness and aluminium losses in Zn-Al alloy due to variation in Aluminium content in alloy.

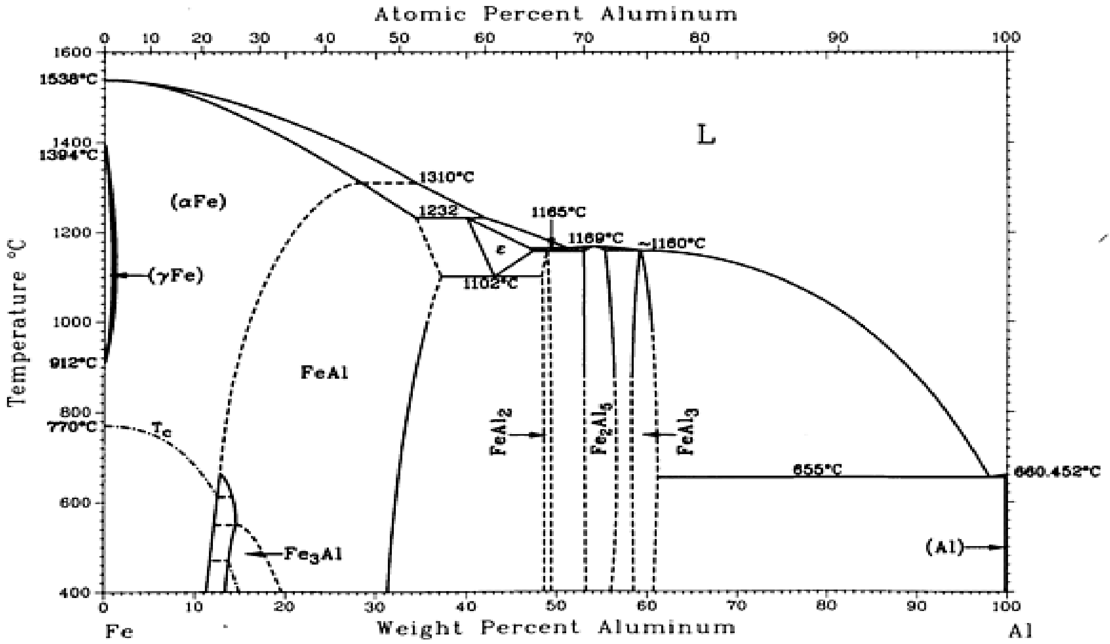
## II. EXPERIMENTAL PROCEDURE

In order to study the effects of aluminium variation in Zn-Al alloy on hardness & loss of aluminium, the following parameters were taken into consideration. The sizes of mild steel samples taken are 25mm*20mm with thickness of 5mm.After that polishing was carried out on all sides of samples with different grades of emery papers. Grades of emery papers used are as follows 1/0, 2/0,3/0..Polished mild steel samples were immersed in CH3OH for 5 to 10 minutes. Then samples were washed in distilled water. Samples were dried in in air for 5 to 10 minutes. These dried samples were ready for

hot dip galvanizing. Graphite crucible was used for melting pure zinc and aluminium in the muffle furnace at 460 to 470 0c with mixture of Zncl2 +Nicl2.Polished sample one at a time was dipped into molten zinc-aluminium in the crucible for 5 to 10 minutes (Batch type dipping) After dipping Mild steel sample in molten zinc-Al in crucible, the crucible with dipped sample was kept in the furnace for maintaining the temperature of molten zinc-Al. Then samples wesre removed and cooled in air. The remaining molten zn-al alloy was poured in square pipe. The specimens for examination were carefully cut from these samples so that section across the thickness is revealed. The specimens were then prepared for microstructural examination by abrading on series of emery papers. These samples then polished on velvet cloth adding 70 micron alumina powder suspension in water. An inverted stage metallurgical microscope was used for this purpose. Zinc-Aluminium coating was done on different surface roughness which showed in the table.

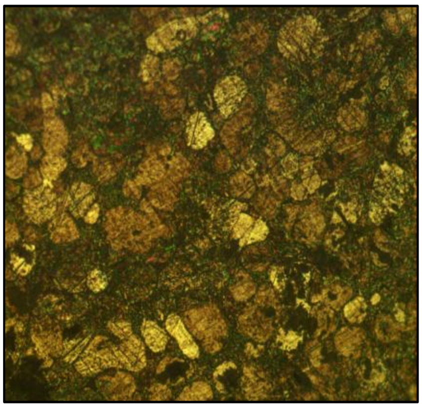
## III. Results And Discussions

Microstructures of Zinc-Aluminium alloy at 500x magnification is presented in figures

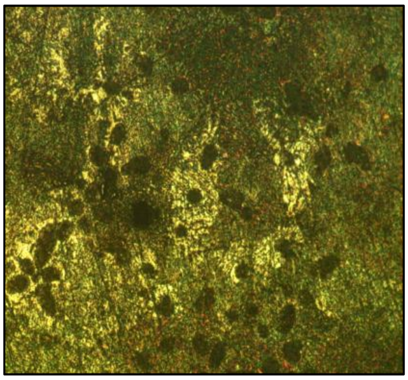



Fe-Al phase diagram

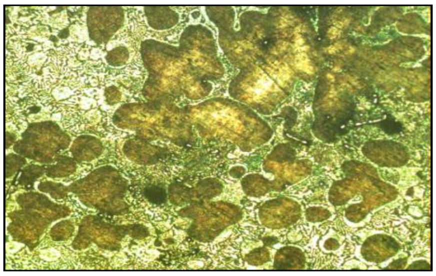
**Microstructure of Zn+2.5%Al**



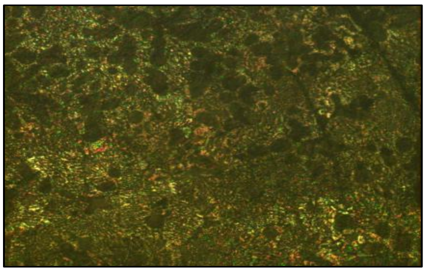
**Microstructure of Zn+4.5%Al alloy**



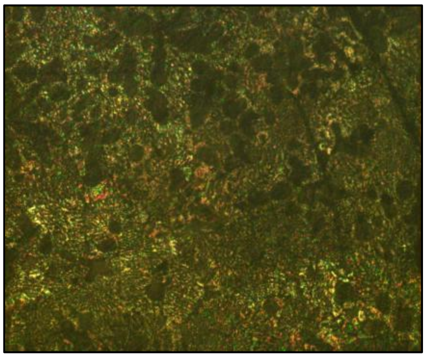
**Microstructure of Zn-6.5% Al alloys**



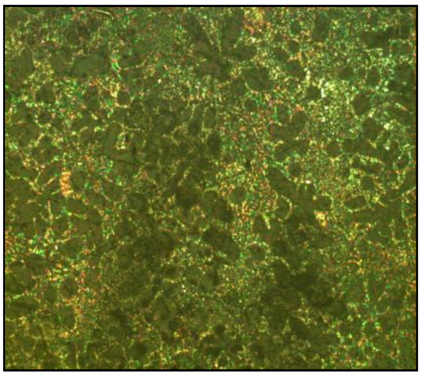
**Microstructure of Zn+8.5%Al**



**Microstructure of Zn+8.5%Al**



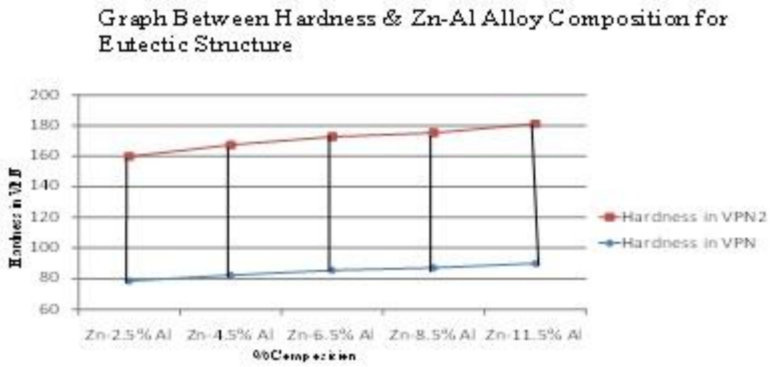
**Microstructure of Zn+11.5%Al**



Microstructures of Zn-Al alloys with variations in Al as2.5%Al, 4.5%Al, 6.5%Al, 8.5%Al and 11.5%Al showing eutectic structure of Zn-Al alloy with eutectic lamellar structures and Zn- Al dendrites in the eutectic structure

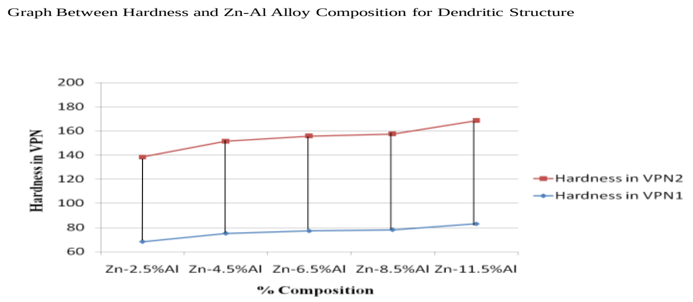
**MICRO HARDNESS VALUES OF EUTECTIC STRUCTURE IN VPN**

| Sr. No. | Composition | Hardness in VPN |
|---|---|---|
| 1. | Zn-2.5% Al | 78.5 to 81.3 |
| 2. | Zn-4.5% Al | 82.3 to 85.1 |
| 3. | Zn-6.5% Al | 85.4 to 87.2 |
| 4. | Zn-8.5% Al | 87.1 to 88.1 |
| 5. | Zn-11.5% Al | 90.0 to 91.2 |




**MICRO HARDNESS VALUES OF DENDRITIC STRUCTURE IN VPN**

| Sr. No. | Composition | Hardness in VPN |
|---|---|---|
| 1. | Zn-2.5% Al | 68.2 to 70.1 |
| 2. | Zn-4.5% Al | 75.1 to 76.2 |
| 3. | Zn-6.5% Al | 77.2 to 78.5 |
| 4. | Zn-8.5% Al | 78.0 to 79.4 |
| 5. | Zn-11.5% Al | 83.1 to 85.3 |




**Result of loss of Aluminum (due to oxidation)**

| Sr. No. | Initial Al % in Zn | Al % After Coating | Loss of Al % |
|---|---|---|---|
| 1. | 2.5 | 2.48 | 0.02 |
| 2. | 4.5 | 4.28 | 0.22 |
| 3. | 6.5 | 6.23 | 0.27 |
| 4. | 8.5 | 7.48 | 1.02 |
| 5. | 11.5 | 8.44 | 3.06 |

## IV. OBSERVATION

- Hardness of eutectic lamellar structure with Al variation in Zn shows increasing order.
- Hardness of dendrites also shows increasing order with increasing Al content in Zn.
- Microstructures of Zn-Al alloys with variation in Al as 2.5%Al, 4.5%Al, 6.5%Al, 8.5%Al, & 11.5%Al showing eutectic structure of Zn-Al alloy with eutectic lamellar structures and Zn-Al dendrites in the eutectic structure.
- Loss of Al increases with increase in percentage of Al in Zn-Al alloy.

## V. CONCLUSION

From the present study it can be concluded that

- Zinc-Aluminium alloys with variation in Al such as 2.5%, 4.5%, 6.5%,8.5%and 11.5%showing the formation of Zn-Al dendritic structure inside the eutectic lamellar structure Dendrides formation is directly proportion to the Al content .
- The loss of aluminium increases with increase in aluminium percentage in Zn-Al alloy
- Hardness at eutectic lamellar structure & at dendritic structure is increasing in order with Al content in Zn.

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